Pressure control device

The present invention concerns pressure control device for maintaining a constant predetermined excess pressure in a fluid dispensing container according to the preamble part of claim 1. The present invention further concerns a method for manufacturing a pressure control device according to the preamble of claim 18.

Such a container with a pressure control device is known, e.g. from PCT patent application WO-A-99/62791. The device described therein is provided for maintaining a constant predetermined pressure in a container which is arranged for dispensing a fluid. The pressure control device has a first chamber and a second chamber, as well as a closing member movable relative to the second chamber for releasing and closing a fluid connection between the first chamber and the container depending on the position of the closing member relative to the second chamber. The first chamber is filled with a gas which, in use, has a higher pressure than the pressure in the container. The second chamber is closed having a gas at a predetermined or reference pressure and is located outside the first chamber. In a first embodiment according to Fig. 2 the first chamber is provided as a cup-shaped holder which is placed upside down in the container and has its longitudinal edge joined together with the bottom and the upright sidewall of the vessel or container. In Figure 3 a second embodiment is shown in which the diameter of cup-like first chamber is much smaller than the inner diameter of the container. The chamber is centrally disposed within the container and joined at its longitudinal edge with the bottom of the container. In Figure 4 a third embodiment is shown in which the same first chamber as in Figure 4 is disposed eccentrically with respect to the container. In Figure 5 a disc is provided slightly below the middle of the height of the vessel and is gas-tightly connected with the inner wall of the vessel through a sealing ring. This disc divides the vessel into two (fixed arranged) parts. A similar construction is shown in Figures 6a and 6b. Further, in Figure 7 the first chamber of pressure control device is designed as a plunger which is sealed to the inner wall of the container with a sealing ring and which can be moved in axial direction within the container. Thus, the plunger divides the

container in two parts, wherein the upper part is filled with the fluid to be dispensed. The fluid connection from the first chamber terminates in the lower part. When the pressure in the container drops since fluid has been dispensed by the push button on top of the container, the plunger is moved upwards because of the pressure difference between the lower and the upper part until pressure equilibrium between the lower and the upper part is obtained again. Therefore, the pressure in the lower part has decreased so that the pressure in the second chamber will be higher and the closing member will open the fluid connection between the first chamber and the lower part, so that the pressure in the lower part will raise. The plunger will then be moved upwards again until a pressure equilibrium is achieved corresponding to the predetermined or reference pressure in the second chamber. Finally, in the embodiment according to Figure 8 the first chamber is of cylindrical design and has an outer diameter corresponding to the inner diameter of the container and thus fitted tightly within the container.

Only the pressure device of figure 7 is movable in axial direction. In all other examples the pressure device is fixedly arranged within the container. The complete pressure control device of figure 7 is designed as a plunger which functions as a movable piston expelling the dispensing fluid. However, the design of the pressure control device is disadvantageous because of its large dimensions so that less of the container can be used for dispensing fluid.

A further important problem of the above described pressure control devices as a separate module is that the first and second chambers have to be pressurized before mounting in a container. This in practice may be very difficult and costly to achieve e.g. in aluminium aerosol cans where the construction is in one-piece and the production lines run at very high outputs. A further major disadvantage is that it has been shown that the pressure in a separate pressure control device which will be mounted afterwards in a container drops to a large extent during a period of some months which is necessary for storage and distribution in the commercial supply chain. In addition, pressurizing of the pressure control device has to be performed with the fluid connection closed in order to obtain a pressure of the

prescribed quantity. Thus the known pressure control devices are not suitable for application in a large industrial scale.

It is therefore an object of the present invention to provide a container with a pressure control device which is simpler in construction and for the manufacturing process, such that the volume of the container can be used to a greater extent. It is another object of the invention to provide a pressure control device for a container which can easily be pressurized after being assembled to the container. This and other objects of the present invention are accomplished by a pressure control system as claimed in claim 1 and by a manufacturing method as claimed in claim 18.

A main advantage of the present invention is that the pressure control device can be pressurized after implementation and filling of the liquid dispensing bottle. Since the second chamber is encompassing the first chamber, a very compact pressure control device will be obtained so that the total usable space in the bottle is much larger as in known embodiments. As the pressure control device can be fabricated in advance and can be implemented easily in existing plastic bottles, the existing production and filling procedures for e.g. cosmetic products can be maintained with only little additional arrangements in the production line.

Further advantages of the invention are disclosed in the dependent claims and in the following description in which an exemplified embodiment of the invention is described with respect to the accompanying drawings. It shows

Fig. 1 a pressure control device in perspective view and in cross-section, wherein the valve is closed,

Fig. 2 the same pressure control device, wherein the valve is open,

Fig. 3 the same pressure control device as in Fig. 1 only in cross-section,

Fig. 4 an exploded view of the pressure control device of Fig. 1,

Fig. 5 a fluid dispensing container with the pressure control device and a movable piston, wherein the valve is closed,

Fig. 6 the same container as in Fig. 5, wherein the valve is open, and

Fig. 7 a fluid dispensing container with the pressure control device and a spray valve with dip-tube arrangement.

Specific numbers dedicated to elements defined with respect to a particular figure will be used consistently in all figures if not mentioned otherwise.

In figures 1 and 2 a pressure control device 1 for maintaining a constant predetermined excess pressure in a container is shown in cross-section and in a perspective view. The device 1 consists of a substantially cylindrical container 2 with a tapered neck portion 3 and a flange 4, on which a ring-shaped insert or closure 5 having a steplike funnel 6 is mounted. The cylinder 2 – indicated as “the second cylinder” in the claims - forms a second chamber 7 of the pressure control device 1. The outer rim 8 of the insert 5 has an outer downwardly directed ring part 9A and an inner downwardly directed ring part 9B, which ring parts include a groove 10. The insert 5 is mounted to the flange 4 of the cylinder 2 by ultrasonic welding. For that reason the inner surface of the groove 10 of the insert 5 has a saw-tooth or fluted structure used as energy directors during the welding process for a very strong hermetic joint. The lower end 11 of the funnel 6 is closed with a small central opening 12. A cup-like piston 13 with an outer sealing or O-ring 14 is inserted in a cup-like cylinder 15. The space between the piston 13 and the cup-like cylinder 15 – indicated as “the first cylinder” in the claims - defines a first chamber 16. The piston 13 has downward a protruding stem 17 with a broader cylindrical end portion 18. The diameter of the central opening 12 is slightly larger than the diameter of the cylindrical end portion 18, so that this portion 18 can slide through the opening 12. The funnel 6 has downwardly a cylindrical clamping portion 19 with a ringshaped barb 20 which clamps a ring-cylinder 21. The upper end 22 of the ring-cylinder 21 pinches a sealing or O-ring 23. In figure 1 the upper rim 24 of the cylindrical end portion 18 is lying against O-ring 23, which is the

closed position of a valve 24, that is formed by piston 13 with stem 17 and cylindrical end portion 18 and pinched sealing or O-ring 23.

The cup-like cylinder 15 is enclosed by a cylindrical clamping means 26 which comprises a cylindrical cup 27 which exactly surrounds the cup-like cylinder 15 and has un upper crown 28 with openings 29 between dents 30. The cup 27 has in its upper closing three vents 31, from which only one can be seen in Figs. 1 and 2. Further, a number of L-shaped small projections or ribs (not shown) are provided on the inside of the funnel 6 which are equally distanced from each other. The projections or ribs are provided at the lateral and the bottom side of the funnel 6. Therefore, there is space between the cylindrical cup 27 and the funnel 6, which defines a passageway from opening 12 up to the upper side of the insert 5.

The cylinder 2 is widened gradually towards its end and has a broader end portion 32 with an inwardly projecting rim 33 on which the end portion of a container rests (see Figs. 5 and 6). The bottom part 34 of the cylinder has a ring-shaped depression 35, which is reinforced at the inner side of the cylinder 2, with a central opening 36, in which a so-called Nicholson plug 37 made of rubber is pressed. The bottom part 34 may have been reinforced by radial supporting ribs, in order to resist the deformation caused by the high pressure during elevated temperature storage conditions. Instead of a Nicholson plug other types of sealing elements can be used, e.g. an alternative type of a rubber bung, or mushroom shaped grommets or so called rubber rope seals, heat staking or use of a ball-bearing such as in cigarette lighters.

Figure 2 shows the valve 25 of the pressure control device 1 in the open position. Figure 3 is a cross-section of the pressure control device 1 as depicted in Figure 2.

In Figure 4 an exploded view of the elements of the pressure control device 1 is shown. Especially, the construction of the cup 27 with crown 28 can be seen more

properly. One can further see that the stem 17 has two grooves 40 and 41, which are provided at opposite sides of the stem 17. In continuation of grooves 40 and 41 there are provided in opposite directions two grooves 42 and 43 at the underside of the piston 13. Thus, in the open position of valve 25, where the piston 13 is lying on the bottom side of the funnel 6, there is a passageway from the open valve 25 along the inner bottom side and the lateral side of funnel 6 over the openings 29 of crown 28 up to the top of insert 5.

In Figure 5 the pressure control device 1 is mounted in a container 50 having a per se known pressure valve 51 and a flexible piston 52 made of a suitable thermoplastic material such as high-density polyethylene which is movable within the container 50. The flexible piston 52 is formed as a cup-like cylinder or dome following more or less the upper contour of the insert 5. The piston 52 has further a broad ring-cylinder shaped sealing 53, which is contacting the inner wall of the container 50 with an upper sealing lip 53 and a lower sealing lip 54. The upper sealing lip 53 is provided as a scraper with a sharp rim so that the liquid filled in the container 50 will be scraped from inner wall of the container 50, so that no material or at most only a very thin liquid film remains at the inner wall. A separate rubber o-ring assembled around the piston 52 can also be considered where a gas tight seal is needed. The sealing lip 54 is wedge-shaped and has a somewhat larger contact area than the upper sealing lip 53. As can be seen the container 50 is formed as a bottle of cylindrical form. The cylinder 2 of the pressure control device 1 is widened to its end so that there is a interference press-fit connection between the inner side of the bottle 50 and the outer side of the cylinder 2. In addition in the neighborhood of the end portion 55 the bottle 50 is laser welded to the cylinder 2 providing a very strong and hermetic seal. Although a ring cylindrical bottle 50 is shown here, other bases like an ellipse or a quadrant can be used for the cylindrical bottle. The bottle can also be oval shaped. The shape of the cylinder 2 of the pressure control device 1 should then be adapted accordingly.

Working

The function of the above described pressure control device is as follows: in the second chamber 7 an inert gas, especially normal air, with an overpressure as required but preferably of around 8 bar is filled in. Valve 24 is in its closed position (Fig. 1). In the first chamber 16 a gas, especially normal air, with a constant predetermined excess pressure of 1.5 to 2.0 bar, preferably at 2.0 bar, is filled in. If the pressure in container 50 drops below the predetermined or excess pressure, which occurs if liquid in the container 50 is dispensed by valve 51, the pressure in the passageway also drops. Thus, there is no more pressure equilibrium between the first chamber 16 and the passageway, and the piston 13 is moved downwardly from the closed position of valve 25 (Fig. 1) to the open position (Fig. 2). Because there is an overpressure in the second chamber 7 of the cylinder 2, there will be an airflow over the passageway to the container 50, i.e. underneath the flexible piston 52 which will be moved upwards until there is pressure equilibrium again between the first chamber 16 and the passageway (or container 50). In the equilibrium situation the valve 25 is closed again and the pressure underneath and the pressure above the flexible piston 52 will be the same. The piston 13 is moved in a reciprocating or oscillating manner to open and close the valve 25 until the equilibrium situation is reached. Since piston 13 and stem 17 are light-weighted the reciprocating movement between the open and closed position of valve 25 is very fast, such that the equilibrium situation is reached almost immediately.

In order to dispense completely all fluid from the container at a constant pressure or continuous flow-rate an excess pressure must be upheld in the container until the end. This can only be afforded if at the end as the last bit of liquid should be dispensed the overpressure in the second chamber 7 is at least equal to the predetermined excess pressure of the first chamber 16. This means that following equation should be fulfilled:

$$P_2 \geq P_1 * (1 + V_1 / V_2)$$

wherein P_1 = the predetermined excess pressure

P_2 = the initial pressure in the second chamber

V_1 = the volume of the container

V_2 = the volume of the second chamber

This means that the smaller the volume V_2 is with respect to the volume V_1, the higher is the overpressure P_2. Thus, since the design of the cylinder 2 is more critical at higher pressures there is a practical limit for the smallest size of cylinder 2 which depends on the material properties, the manufacturing methods, etc.

In a practical example the volume of the container V_1 is 150 ml, wherein the volume of the liquid to be dispensed is to a maximum of 90 % of the container volume, i.e. 135 ml. The overpressure P_2 of the second chamber 7 is initially 8.0 bar and the working or predetermined excess pressure P_1 is 2.0 bar. The volume V_2 of the second chamber 7 is 50 ml.

The required working pressure P_1 is dependent on the viscosity and or other physical properties of the liquid to be dispensed. A typical working pressure needed for low or medium viscosity gel or cream (e.g. cosmetics) is 1.5 to 2.0 bar, for post-foaming gel in a pressurized formulation is 3.0 bar, for high viscosity filler (e.g. acrylic resin) is 2.0 to 2.5 bar, a wet liquid spray is 3.0 bar, a fine liquid spray is 4.0 to 5.0 bar, and a dry to very dry liquid spray is over 6.0 bar.

In the last case the overpressure P_2 is 24.0 bar if the volume V_1 of the container is 150 ml and the volume V_2 of the second chamber 7 is 50 ml. Therefore the construction of the cylinder 2 of the pressure control device 1 has to be very stable in order to withstand such high overpressures. Also the governmental regulations for pressurized containers must be fulfilled, which concerns the stability and choice of the material used for the cylinder 2, etc. Therefore, the process for producing the above described pressure control device 1 is also very important, which is described hereinafter.

In Figure 7 a fluid dispensing container 60 is shown in cross-section, in which the pressure control device 1 is mounted in a similar manner as in the container 50 of Figs. 5 and 6. At the upper end 61 of the container 60 a conventional dispensing

valve 62 with a push button actuator 63 comprising a spray nozzle 64 is mounted by circumferential ringshaped rim 65 which is crimped to the upper end 61. The lower end 67 of the valve 62 is provided with a hollow dip-tube 68 of a plastic material such as polypropylene or polyethylene. The length of the dip-tube 68 is long enough that the lower end 69 merely contacts the cylindrical cup 27 of the pressure control device 1 (cf. Fig. 1). The dip-tube may also be positioned in between the outside of the cylinder and the inside of the container wall. The lower tube end 69 may be cut-off obliquely so that blocking thereof by a too close contact with the surface of the cylindrical cup 27 is prevented. The working of the container 60 is similar as for the container 50 of Figs 5 and 6.

It has been proven in a series of practical tests that the pressure in the container 50 or 60 remains constant independent from the filling rate, i.e. during dispensing the fluid product the predetermined excess pressure remains constant until all fluid is dispensed.

Clearly the container 50 with the flexible piston 52 is more suited for fluid with a higher viscosity like a cream or gel, whereas the container 60 with the spray nozzle 64 is more suited for low-viscosity fluid like airfreshners, deodorants, spray paints and the like.

<u>Manufacturing process</u>

The cylinder 2 of the pressure control device 1 is preferably injection blow moulded from polyethylene terephthalate (PET). The main advantages of the injection blow moulding process for producing the cylinder 2 is that different sizes can be produced with the same tooling, or with minimal changes, and that the orientation of the stretched PET material during the blowing process leads to a higher crystalline structure which gives high strength and good gas barrier properties. It has been proved that the construction of the cylinder 2 with neck portion 3, flange 4 and widened or broader end portion 32 with a wall thickness of

typically 1.5 to 2.0 mm is very strong and most suitable for containing high gas pressures.

The neck portion 3 remains the same for all sizes of the cylinder 2 which allows the efficient standardization of components and manufacturing processes and assembly equipment. The central opening or hole 35 is made in the bottom of the cylinder 2. This can be done by drilling or, which is more advantageous, during the injection blow moulding process in that the outer shape of the moulding tool has a pin at the bottom for shaping the central opening or hole 35. For the laser welding process mentioned above a tapered area on the outside diameter of the cylinder is provided in order to obtain an optimal interference press-fit with the container or bottle 50.

The other parts of insert 5, i.e. the funnel 6, the cup-like piston 13, the ring-cylinder 21 and the cylindrical clamping means 26, are made by injection moulding of any suitable synthetic material like PET or the like. The cup-like cylinder 15 made of aluminum is positioned at the correct position over the piston 13 with surrounding O-ring 14 under air pressure, and three of four inward indentations are made at the open end of the cylinder 15 to prevent escape of the piston 13. In this manner the first chamber 16 is maintained at the predetermined excess pressure. Thereinafter the cylindrical clamping means 26 is put over the cylinder 15, whereas the air between the cylinder 15 and the cylindrical cup 27 will escape through vents 31, and is snapped in position in the funnel 6. As can be seen in Figures 1 and 2, for this reason there is provided a small ring groove 60, in which outer ring parts 61 of the crown dents 30 can be snap fitted. Alternatively, the cup-like cylinder 15 can also be made of PET or any other hard synthetic material. Instead of indentations the outer edge of the cylinder 15 can be assembled into position by ultrasonic welding or some other suitable method.

The container or bottle 50 is injection stretch blow-moulded (ISBM) from a proper pre-form made of any suitable synthetic material like PET or the like. The PET pre-form has already the shape of a bottle in a smaller format. Pre-forms may first

be made separately on very high output production scale and are therefore very economical. The ISBM process has the same advantages of the abovementioned injection blow-moulding process used for producing the cylinder 2, but with the additional important benefit in that the PET material is stretched bi-axially, that is both radiallly and lengthwise, which gives rise to even better stretch and gas barrier properties even with a thin wall thickness of typically 0.3 to 0.6 mm depending on the container design. After stretch blow-moulding the end part of the container bottle 50 may be cut-off to provide an open end for receiving the piston 52 and cylinder.

The flexible piston 52 is assembled into the bottle 50 and the bottle 50 with its open end portion 50 is put over the cylinder 2 of the pressure control device 1. In order to obtain a hermetic seal between the bottle 50 and the cylinder 2, the bottle 50 is laser-welded to the cylinder 2. For this reason the bottle 50 is made of a transparent plastic material like PET and the cylinder 2 is at least impregnated at a small distance from the bottle end portion 53 at a ring-cylindrical circumference with a infrared or laser energy absorbing material known as "carbon black". The bottle 50 with the cylinder 2 is turned over its longitudinal axis during a laser beam is directed perpendicularly towards the outer surface of the bottle 50. The used semiconductor laser equipment is the NOVALAS-C system of Leister Process Technologies, Sarnen, Switzerland with a wavelength of 820 nm. The power of the used laser beam was 25 Watt (continuous), the rotational speed was 3.5 revolutions/sec and the laser beam was applied during approximately 10 revolutions.

Although laser welding has been proven as giving the best results for joining the pressure control device to the bottle 50 other suitable joining methods, like ultasonic welding or gluing with an appropriate plastic adhesive can also be used.

The main advantages of the described manufacturing method is that the pressure control device can be produced and its first chamber can be pressurized and delivered to the manufacturer of the container, and the manufacturer can produce

the container or bottle by injection stretch blow-moulding, which is a standard known process, cut-off the bottom of the container or bottle, join the pressure control device with the bottle e.g. by laser welding, insert the pressure valve 51, fill in the liquid over the pressure valve 51, and finally pressurize the second cylinder through the rubber plug 37 in a conventional manner. The additional production steps can easily be introduced in the known production and filling processes for aerosol containers as used in cosmetics or the like, wherein e.g. the liquid product is filled in through the open neck of the container or through the dispensing valve 51.

A further advantage of the invention is that, since only normal air or any other suitable inert gas is used for the pressure filling, the process facilities, equipment and manufacturing environment and operating procedures do not need to take account of the special safety requirements normally needed for dangerous flammable propellants.

List of reference numbers

1	pressure control device
2	cylindrical container
3	tapered neck portion
4	flange
5	ring-shaped insert
6	steplike funnel
7	second chamber
8	outer rim
9A	outer ring part
9B	inner ring part
10	groove
11	lower funnel end
12	central opening
13	cup-like piston
14	sealing or O-ring
15	cup-like cylinder
16	first chamber
17	protruding stem
18	cylindrical end portion
19	cylindrical clamping portion
20	ringshaped barb
21	ring-cylinder
22	upper end
23	sealing or O-ring
24	valve
26	cylindrical clamping means
27	cylindrical cup
28	upper crown
29	opening
30	dents
31	vent
32	broader end portion
33	inwardly projecting rim
34	bottom part
35	ring-shaped depression
36	central opening
37	Nicholson plug
40	groove
41	groove
42	groove
43	groove
50	container, bottle
51	known pressure valve
52	flexible piston
53	upper sealing lip
54	lower sealing lip
55	end portion
60	dispensing container, bottle
61	upper end
62	pressure valve
63	push button
64	spray nozzle
65	ringshaped rim
67	lower valve end
68	dip-tube
69	lower tube end